they enter the prisms. A small telescope is added to better view the image, and a micrometer to measure. Some instruments are so made as to admit of the direct comparison of the spectra of two objects. Thus the spectrum of the Sun, or of a star, may be directly compared with that of a known substance heated to incandescence. There are spectroscopes specially constructed for special purposes of analysis.

The spectrum of the Sun, for instance, is crossed at right angles with its length by innumerable lines. The same substance, when in the same state, always gives the same bands and lines,—peculiar to itself, and in the same places in the spectrum. It follows that spectrum-analysis of the rays from luminous bodies throws light on their chemical constitution and physical condition.

Thousands of the dark lines of the solar spectrum have been mapped, that is their places in the spectrum are recorded. The presence in the Sun, of hydrogen, sodium, iron, magnesium, copper, zinc, calcium, nickel, etc., is established beyond all question.

Not only can the presence of a certain element in sun or star be demonstrated, but also the physical state in which it may be found, whether as a solid, or a liquid, or as a gas.

As the position of any given ray in the spectrum depends upon its length of wave, it is evident that if the luminous body is approaching rapidly the rate will be increased. This principle is applied to determine whether a star is approaching or receding. In this way the rate and direction of motion of certain stars have been ascertained.

Spectrum-analysis applies to compounds, as well as to the substances now known as simple elements. When the temperature is increased sufficiently the characteristic

spectrum of a compound changes into the lines peculiar to its constituent elements. It is found that when submitted to still higher degrees of heat the spectra of the so-called elements show a tendency to break up in the same manner. Are they also compound? Is there more than one primary element?

Solid, or liquid, bodies give out continuous spectra. Gas gives out bright lines only. When light from solids or liquids passes through a gas, the gas absorbs those rays of which its own spectrum consists.

It may be considered proven, that we have to deal in the stellar regions with the same elements we are in close contact with in the Earth, and that the distribution of these substances is co-extensive with that portion of space that is known. Lockyer aptly calls the lines of the spectrum, "The cypher of the Universe."

CHAPTER V.

FORCE AND MOTION.

WHEN we speak of a law of nature, we do not mean a decree or order given by a superior authority, but simply the orderly, uniform course of nature; any certain set of conditions always being followed by the same phenomena. The law of gravitation, is recognized by that quality of matter that causes the mutual attraction of bodies. The three laws of motion as laid down by Sir Isaac Newton, are examples of natural "law:" (1) If a body be started in motion, and if no force acts upon it, it will continue to move in the same direction and with the same velocity. (2) Change of motion is proportional to the acting force, and takes place in the direction of the straight line in which the force acts. (3) To every action there is always an equal and contrary reaction. The laws of Kepler might be mentioned: (1) The orbit of each planet is an ellipse, the center of the Sun being in one of the foci. (2) The radius-vector, or line drawn from any planet to the Sun describes equal areas in equal times. (3) The squares of the times of the planets revolutions are as the cubes of their mean distances from the Sun.

The important discovery by Newton of the law of gravitation, and that it applied to the heavenly bodies, that they attract each other directly as their respective masses and inversely as the square of their distances, is merely the recognition of existing principles and facts. It is not explained why masses of matter attract each other.

It has been suspected that gravitation is a result of the activity of matter, and acts in proportion to that activity. Along this line we have a new theory of gravitation, by Singer and Berens, that: "Two bodies in different states of excitation and free to move, will move toward each other, the intensity of attraction being proportional to the difference in excitation." (*Popular Science Monthly, Oct., 1897.*) Bodies in the same state of equilibrium would then have no attraction of gravitation. Few, if any, such bodies can be found. There can be little doubt that this is the direction in which research may reasonably be expected to eventually lead to satisfactory results.

When a body is at rest it will remain so until force is applied; and when once set in motion it takes a resisting force to stop it. This law applies relatively, as in the case of terrestrial objects; but in the broader application there is no such thing as a state of absolute rest. The solid rock is gradually being reduced by the elements,—and is swept along with the earth and the sun through space. There is motion everywhere.

Where a body strikes another, its motion is arrested; the force causing the motion is not lost, but is converted into heat—another form of force. The heat force thus developed is the exact measure of the force causing the motion. This is the case whether the moving bodies are atoms or stars,—moving slowly or rapidly. The principle is therefore universal that force is conserv-

ed and cannot be destroyed. Its conversion into other forms shows that the different forms of force are correlated.

If heat is employed, with engines or otherwise, to lift a great weight, the weight in coming down, with whatever velocity, will give out exactly the same amount of heat. It has been calculated that the force developed by the contraction of three hundred feet a year in its diameter would supply all the heat the Sun sends out. The working energy of a steam engine exactly equals the force represented by the heat of the steam.

The amount of force, like the amount of matter in the Universe, can neither be increased nor diminished. It can be changed from one form into another, heat into electricity, electricity into heat, or either into motion and the reverse, and so on indefinitely.

The doctrine of the correlation of force recognizes the fact that all the different kinds of force in the Universe are connected together, being manifestations, under different conditions, of the active properties of matter. It implies the unity of matter and force. Such a thing as matter without force, or force without matter, is unknown.

If the attraction of the Sun should cease, the planets would leave their orbits, in a tangent, and continue on in a straight line into space until stopped by collision with other bodies, or by a resisting medium. If after the original impulse was received from the rotating nebulous mass from which the planets were formed, the tendency to continue on in the same direction were removed, the attraction of the Sun, acting alone, would cause the planets to fall to that luminary. The two forces, c~~o~~ntrifugal e/ e/ and c~~o~~ntripetal, continuing as they must in the nature of things to act together, the planets move in their orbits balanced midway between the two. If many forces are acting together the result is correspondingly complex.

No force, of whatever kind, ever proceeds from nothing, and without cause, but it always has its origin and cause in some preceding form of energy. It is therefore clear that motion is universal and eternal like matter and force.

Some of the most important operations in nature are carried on by the motion resulting from the attraction and repulsion of molecules. That the little bodies have polarity, like larger masses, which influences their motions, will not be questioned. Molecular attraction acting at infinitely small distances, is the cause of cohesion. The action of the molecular forces keeps the molecules together in mass, although they do not actually touch each other. The ceaseless clash of atoms and molecules pervades alike organic and inorganic matter. Their motion is the complex result of the ever active internal and external forces; their constant action and interaction. Their motion is converted into heat, electricity, etc., which are also forms of motion, and have their mechanical equivalents.

The chemical separation of atoms develops energy that is transmutable into heat, or other forms of force. Animal heat and vital force represent the energy of the food consumed, and that in its turn is mostly derived from the energy of the Sun. Solar energy is stored in wood, coal, food, water elevated above the sea level, and in water and air in motion.

As the Sun and Earth are radiating heat into cold space, it follows that the time will come when their energy will be dissipated, and the life of the solar system will come to an end,—a matter of less importance to the Universe than is the death of a limb of a tree to an extensive forest. Other systems and other limbs have for this reason a greater supply of fuel and food.

Vital forces being correlated with chemical and other physical forces, and like them, being properties inseparable from matter, and therefore as here manifested constituents of the solar system, must share its fate.

The evolution of the living parts of the Universe is accomplished through the supply of nourishment derived from the so-called dead, or decomposing portions. In all this changing process, there can be no atom of matter, or its inherent force and potency, either lost or gained. To every excitation of energy above the average level, there is a corresponding depression elsewhere, and the ebb and flow is universal and eternal.

CHAPTER VI.

NEBULÆ.

DOUBTLESS the reader has noticed that the preceding chapters are of a somewhat preparatory or introductory character. An attempt has been made to clear the way for a broader conception of the real nature of the celestial bodies, before proceeding to anything like systematic description. We are trying to get better acquainted with the matters with which we have to deal.

I purpose to take up, first the nebulæ, then the stars, solar system, etc., in the order of their evolution. It was thought to be the best and most natural way of treating this great subject to begin with the primitive or commencing stage of world-life. This plan is also in accordance with the general scope of this work, it being an attempt to aid in arousing popular interest regarding the more advanced teaching of Science. To better do this I begin with the more simple forms of matter and go forward to the more diversified and complex.

The plan necessarily includes a brief review of the evolution from primitive matter upward, and the return to the same state. It must not fail to call attention to the eternal continuity of such cosmical changes.

The ancients knew nothing of the nebulæ. They are not even mentioned in their most elaborate and popular theories of creation. The stars were mentioned among

the "alsos," but the nebulæ, never. Yet, careful investigation has proved them to be the grandest and most important masses within our knowledge. Our earth, the solar system, the starry heavens visible to the eye, sink into insignificance when compared with them. We have in mind the immensity of their extent and the promise of their future.

When looking for nebulæ, the Moon must be absent and the air clear and steady. When astronomical objects are seen near the horizon, we look at them through about 4,000 miles more of dust-laden air than we do when they approach the zenith. Therefore, as a nebula is a dim object at the best, look for it only when it has reached a favorable altitude.

At least two of them in our northern sky may be seen dimly, with the naked eye. These we will first mention. Exceptionally good eyes may detect a few others. There are some 5,000 visible with telescopes, and the list increases with the improvements of the instruments. The use of photography in a systematic manner will probably add thousands to the catalogue. There are a few dense clusters of stars that might with the naked eye be mistaken for nebulæ.

In the splendid constellation of Orion, below the lowest of the three stars in a straight line called "the belt," lies the great nebula of Orion, readily visible to the naked eye. It looks like a dim hazy light, and may easily be mistaken for a tailless comet. With a telescope having only a two or three inch object-glass and a low power eye-piece it is a most wonderful object. It is irregular and branching, and more luminous in some portions than in others. The margins fade away in the distance. A most interesting multiple star, known as Theta Orionis, in the dense part of the nebula, is by such a small telescope,

resolved into four distinct bodies. In large instruments two of them are seen to have smaller companions. This object is sometimes called the trapezium of Orion from the figure formed by the four principal stars. At one time Lord Rosse, with his great reflecting telescope, thought he had succeeded in resolving the part of the nebula about the trapezium into stars. Fifteen years later he seemed inclined to attach little weight to the observation. The spectrum-analysis of Huggins showed the presence of gases, including hydrogen. The later work of Lockyer, and others, has added iron and magnesium.

Bright lines of other metallic vapors and of hydrogen, being generally absent in the spectra of the nebulæ, Lockyer concludes that "The temperature and electrical excitation of these bodies is at a minimum."

One of the grandest in the heavens, so plain to the naked eye that it is often mistaken for a comet, is the great nebula in the belt of Andromeda. To find it, start if you please from the Pole Star, in the opposite direction from Ursa Major, or the Great Dipper, and at about the same distance from the pole, stop to admire the bright constellation, Cassiopeia. Its principal stars form a figure that somewhat resembles an inverted chair, or an irregular W, with its opening toward the Pole Star. Still farther from the pole, twice as far, you observe four stars forming a great square,—Pegasus, or the flying horse. The star in that corner of the square nearest Cassiopeia is in the head of Andromeda. Now, a line drawn from the farther star diagonally through the square and extended will point to the belt. It is curved, and consists of a bright star and two dim ones. Near the outer small star is the great nebula. Passing on in the same direction to the vicinity of Cassiopeia will bring you to Perseus, a constellation containing many rich fields. One of the

finest clusters in the heavens is located here. To the eye it looks hazy like a nebula. The great nebula is about midway between Perseus and Pegasus.

The Andromeda nebula is long and oval, and brightens toward the center. It has not been resolved into stars by the best telescopes, although with small instruments it is still a very interesting object. Huggins found its spectrum to indicate that it is not gaseous.

The best long-exposure photographs show it as elliptical, with broken spirals almost ring-like, and faint irregular nebulous extensions to immense distances. Some of the spirals are much more dense in some places than in others and seem to be gathering in masses. Very little if any stretch of imagination is required for one to entertain the belief that in this nebula we behold the spectacle of the birth of stars.

This instructive feature of the spiral nebulæ, viz., the tendency of the ring-like spirals to break up into secondary masses evidently revolving around the central mass, is still more clearly shown in the nebula in Canis Venatica. In this famous object the feature in question is too pronounced to admit of doubt. In small telescopes it is seen as a misty spot, about three degrees, (the length of the belt of Orion,) south from and preceding Alkaid, the end star in the tail of the Great Bear, or handle of the dipper. Any direction from the North pole of the heavens is South, yet, the best time to trace and identify constellations, is when they are on the meridian.

North-west of the square of Pegasus we come to Cygnus, a constellation extremely rich in telescopic stars. It lies along the Milky Way, the principal stars forming the figure of a cross, with the brightest star in the top of the upright piece. Directly west of Cygnus is a very brilliant white star, Vega, in the constellation Lyra. Two

small stars about two degrees apart, on the east of Vega form with it a triangle with the great star at the apex. Half-way from Vega to the star in the foot of the cross in Cygnus you pass two stars about two degrees apart, Beta and Gamma, in Lyra. The only annular nebula accessible by common telescopes lies between these two stars. This wonderful object is probably in shape a perfect ring. It lies inclined sufficiently to appear to us slightly oval. A light nebulosity is seen in the interior of the ring, but no central body.

It is well to remember our bearings, doing the best we can toward "blazing" our way, for we will want to return to this captivating region.

While we are so near, take a look at Hercules, the constellation next west of Lyra. You will recognize it by a trapezoid of stars of the third magnitude. They are on a line with Vega and the star of the second magnitude in the cross in Cygnus. Between the two stars forming the west side of the trapezoid is a superb object, just visible to the unaided eye, and seeming to be a nebula when viewed with low powers. It is, in fact, a splendid globular cluster of stars. This is one of the most interesting objects in the heavens. It is no exaggeration to say that in this comparatively dense cluster there are thousands of stars,—a galaxy in itself. Compare it with the easy cluster previously mentioned, in Perseus.

When Lyra is in the zenith turn your back on the northern sky and stroll to the southward. The red, first-class star Antares, is in the constellation Scorpio, the most conspicuous in that region. Half-way between Antares and Beta Scorpio, the second-magnitude star north-west of it, is an ther fine object. Dwell long in Sagittarius, next east. See that beautiful cluster near the handle of the "little dipper," and sweep around and

along up the Milky Way. Much time may be profitably spent at almost any point along the Galaxy.

Find Beta Aquarius by drawing a straight line from the north-east star in the square of Pegasus through the south-west star. Continue on about the same distance and reach Alpha Aquarius, a star of the third magnitude, and then half as far and come to Beta, same magnitude. About six degrees north of Beta is a fine nebula, and about the same distance south-west is one of the finest of a class of nebulæ called planetary, from their resemblance to the disks planets show in the telescope.

The "dumb-bell" nebula is located in Vulpecula, and may be found by extending a line drawn from the ring nebula in Lyra through Beta Cygni, the star in the foot of the cross, about the same distance farther, and thence some three degrees north. This remarkable object has been the center of much study and speculation.

Near Merak, the pointer farthest from the pole, in the Great Bear, is a large, pale, planetary nebula.

Nebula No. 3249 of the general catalogue, in Coma Berenices, as photographed by Roberts, shows nucleous to be a nebulous star of the 12th magnitude. Surrounding the nucleous at a great distance is a "well-defined ring, and in the ring several star-like condensations of nebulosity are involved." Outside this ring is another fainter one, and beyond is a third still fainter.

Materials for profitable investigation are present in profusion on every hand. We are conscious of marked moral and intellectual expansion as we stand uncovered in the presence of the Universe. The ego is lost and absorbed.

Herschel was the first to discover extensive, faint, irregular nebulosities. Patches of this diffused nebulous matter are numerous. They are sometimes comparable to constellations in the number of square degrees covered.

Sometimes the diffused matter is associated with the denser nebulæ, or with stars, or it may be found in detached masses.

These nebulous clouds, among and beyond the visible stars, reveal one of the first steps in the concentration and evolution of matter. As indicated by the spectroscope they consist of finely comminuted particles, substantially the same as meteoritic dust. The processes of disintegration have performed their work. The old material has resumed its original form, its elementary state, and is once more ready for rebuilding.

The atoms and molecules are constantly moving like the particles of powdered indigo referred to. They no sooner separate than they begin to recombine. They collide with each other and the impact produces heat, and the forces are aroused into action that assists re-aggregation. Streams of meteorites, sooner or later, come in collision. The collisions develop heat and light. As new masses increase in size and power, larger particles are attracted—and from greater distances. So new condensations and combinations inevitably result from the collisions of atoms, molecules, two or more small or large bodies, or streams of meteorites.

It is not to be presumed that amid the activities of the larger stellar masses any of the small particles, or any molecules, wherever situated, are ever at rest. Even the larger planets are perturbed by the attraction of the Sun and the other planets. A notable example was the discovery of the planet Neptune by taking advantage of the measurable disturbance of the motions of Uranus caused by the attraction of the unknown planet.

Comets and meteorites are captives to the larger bodies around. Each particle or planet, and each fragment or molecule acts upon others and they upon it. When their

forces are active they attract, cohere and build up, and when their heat becomes lost by radiation, and their powers dissipated, they fall to pieces. The resulting dust comes within the attraction of nebulæ, suns, or planets, and falls to them, or, escaping and eventually coming in collision with other dust becomes a factor in the formation of new worlds. Activity no sooner reaches its limit in one direction than it begins in another.

The weight of evidence favors the nebular hypothesis as supplemented and strengthened by the meteoritic hypothesis of Lockyer. If, then, the diffused nebulosity is the first step, we ought to be able to arrange the 5,000 known nebulæ in groups showing gradual evolution toward the formation of stars. That such is the case has been recognized by advanced astronomers since and including the elder Herschel.

It is a common thing for nebulæ to show irregular condensation,—thin in some places and dense in others. Some have a single nucleous, others two or more. So we have single, double, and multiple nebulæ. They are seen in all stages, from irregular, irregular rounded, round, round with central nucleous, up to globular. It would be a very small nebula that would go to make only one star. The greater ones contain the material and potency for numerous sun-systems. The telescopic results are confirmed by the spectroscope, that instrument proving the condensation and evolution of nebulæ. The two noble instruments agree, and the verdict accords with the orderly march of Nature. Neither is reason antagonized.

Photographs of the nebulæ also confirm this opinion. Details, undetected by the eye, have been brought out by long exposure of the sensitive plate, and photography is justifying the confidence and hope of Draper. The se-

crets it has revealed all lie along the line of natural evolution,—like those yielded by the Andromeda and Canis Venatica nebulæ.

There is variety amid the general sameness. There are marked differences in the modes of separation of secondary bodies fròm their primaries. As the conditions are never exactly the same, this was to have been expected. In some the central body is large and the secondary ones small, as in the solar system. Other nebulæ divide into two nearly equal parts. In the final globular condensation, accompanied by the loss of heat, processes and results are similar.

Differences in volume, in molecular activity, in the advent and direction of intakes of meteoritic streams, in the attraction of neighboring bodies and the tides caused thereby, lead to differences in the sizes, distances, etc., of the stars formed therefrom. The *natural* rules in this broad realm, as elsewhere.

All drawings of the nebulæ have proven mòst unsatisfactory, and successful photographs of them are of very recent date. Astronomers have therefore not been in position to record changes in any particular object. Most of the changes are so gradual that many centuries might be required to obtain data to warrant drawing a conclusion from observations on one object. However, this delay is by no means necessary.

We do not have to watch the growth of an oak tree for a century to know its history. When we enter a forest we see its mates in all stages of growth from the acorn to the mature specimen. It is as true of the nebulæ as of the forest. Taken in the aggregate the lesson is not to be mistaken. We have the complete connection from the diffused disintegrated material to the star that shows a spectrum like our own star-sun. There is no break.

Neither is there any dividing line between a nebula and a nebulous star, nor between a nebulous star and one like our sun. There is no region of the stars, and beyond a region of nebulæ. All forms exist together in space and time, and are intermixed, as we find all stages of the growth of trees in a forest present together. The continuity is complete.

This living picture represents the life-history of a nebula, from its birth amid the heat and force—developing collisions of its atoms and molecules up to the time when it may be called a star. During this long period there has been a great increase of heat and light. The constant clash of its particles within itself and with accessory streams has produced these effects.

The energy developed by the aggregated activities has far exceeded the losses through radiation. Whether in the form of heat, light, magnetism, gravitation, or other forces it has been effectually stored. Not, indeed, for a designed purpose for future use, but simply because energy, like matter, is indestructible. It cannot escape.

CHAPTER VII.

STARS AND STELLAR SYSTEMS.

WE are now to consider one of the most important links in the chain of evolution, viz.,—The stars that shine by their own light, commonly called fixed stars. All those visible to the naked eye are thus designated excepting five or six planets.

That branch of astronomy which has to do with the naming of constellations, groups, and the principal stars and determining with more or less accuracy their position in the heavens, is of ancient date. A catalogue of stars was made two thousand years ago. The Greeks must be credited with the first accurate, really scientific knowledge of the stars.

Thales, 640 B. C., had made a fair beginning in this the oldest of the sciences, and much advance was made in the following eight centuries. But, alas for the hopes of the Greek and Roman sages, the foundations of their civilization were fast being undermined, and all further progress for the time checked. The world was given over to political dissensions, disastrous and devastating wars, and fruitless theological contentions, persecutions and vain imaginings. The period known in history as the Dark Ages followed, from which, thanks to Science, Europe has been for a few centuries emerging.

While the dense darkness of the Middle Ages brooded over Europe, the Arabs, then known as Saracens, culti-

vated the sciences of mathematics and astronomy, and saved to mankind part of the old knowledge, enriched by their own observations.

From all this it has come to pass that the names we find among the stars are, as it is proper they should be, Greek and Arabic. The principal stars are thus named, and the Greek alphabet is used in designating the stars of each constellation in the order of their apparent magnitudes. When the alphabet is exhausted the Arabic numerals are used.

In calling particular attention to some of the more brilliant constellations, and more interesting and instructive objects in the sidereal heavens, it is thought best to begin with the Great Bear, with which we are already somewhat acquainted. We need no introduction to the seven bright stars forming the figure of the Great Dipper. Mizar, the middle one of the handle, is a beautiful double-star. Alcor, very near Mizar, and visible to the naked eye, and a still smaller star, are seen with Mizar and companion in the same telescopic field with a low power, and make a fine group. An ordinary spy-glass just separates the companion star from its principal. They doubtless form a binary system, with a long period of revolution.

The two outside stars in the bowl of the dipper, called the pointers, point to the Pole Star, in the constellation Ursa Minor, or the Lesser Bear. Polaris, the pole star, lies at the end of the handle of the little dipper, and is itself a double-star, easy for small telescopes.

The two stars constituting the bottom of the Great Dipper point toward the very brilliant star, Capella, in Auriga, or the Wagoner.

A line drawn from Mizar through Alkaid will point toward, and serve to identify Arcturus, a star of the first

magnitude, in Bootes ; and also Corona Borealis, or the Northern Crown, the stars of which form a circular figure or wreath. Arcturus, two other principal stars in Bootes, together with the star of the second magnitude in the Crown, form a large Y, with Arcturus at the bottom. Mirac, the one in the center of the Y, is a fine double,—probably a binary system. The components are beautiful in color, the larger one yellow and the smaller blue. This star is sometimes used as a test for small telescopes.

The sickle, with the large star, Regulus, in the handle, forming part of the constellation Leo, lies west of Arcturus and south of Ursa Major. South-west of Bootes is Virgo, with many interesting double-stars and nebulæ, and one star of the first magnitude.

East of Corona Borealis we return to Hercules, where are a number of fine objects,—then to Lyra. Vega has a minute companion, very close,—a test for a good telescope of about three inch aperture. Epsilon, the northern-most of the stars near Vega, forming the small triangle, is a grand double-double; the lowest powers separate it into two, and moderate powers show each of these to be a fine binary system. There are several other very faint points in this most instructive group.

Beta Cygni, referred to in the preceding chapter, is one of the loveliest colored double-stars in the heavens, and fortunately within easy reach of small instruments. The larger constituent is of a golden yellow, and the companion a light blue. The colors are better seen by putting the pair a little out of focus.

Nine degrees north-east of Algol is Algenib, a bright star in Perseus, which with Almaack, in the foot of Andromeda makes a right-angle at Algol. The open side of the angle is toward Cassiopeia. The head of Andro-

meda is in the great square of Pegasus; the belt near the great nebula, and at about the same distance toward Perseus you find Almaack, and readily distinguish the perfect right-angle, and Algol, the most celebrated of the variable stars.

Algol is a star of the second magnitude for about two days and thirteen hours, when it commences to decline in brightness, and in the course of nearly three and one-half hours reaches the fourth magnitude, where it remains for eighteen minutes, then begins to increase, and in the same time it took to decline, regains its brilliancy. Its period, accurately stated, is two days, twenty hours, forty-eight minutes and fifty-five seconds. Almaack is double with a moderate sized telescope and triple with large ones.

Rigel, the great star in the foot of Orion, is a double-star affording a fair test for small instruments, under favorable atmospheric conditions. The lower star in the belt of Orion is triple, and Betelguese, the bright star in the east shoulder, is variable.

The three stars in the belt of Orion point north-west to Aldebaran and the Pleiades, in Taurus, and south-east to the brightest star of all, Sirius, the dog star, in Canis Major. East of Betelguese is Procyon, a first magnitude star in Canis Minor. North of Procyon are the bright stars Castor and Pollux, in the heads of the Twins, or Gemini. East of Gemini lies Cancer with the interesting naked eye cluster, Præcepe.

Aldebaran and the Hyades make an imposing cluster as do the Pleiades. The latter when a low power eye-piece is used, affords rich fields. Aldebaran has a minute companion.

The finest double-star of all, in some respects, is Castor, the northerly one of the two principal stars in Gemini.

The components are of nearly the same magnitude and easily separated with a small telescope. In this pair, as in many others, a movement of revolution has been observed.

Antares, the great red star in the heart of Scorpio, is a double that will repay you for your time spent on it when conditions are favorable.

Here are the names and periods of revolution of a few double-stars: Kappa Pegasi 11.04 years; Delta Equulii 11.05; Beta Sagittari 18; Zeta Herculis 34; Eta Corona Borealis 42; Sirius 52; Alpha Centauri 81; Mu Bootes 219; Delta Cygni 377; Castor 1001; and Zeta Aquaris 1624 years.

Let the reader go ahead; he will find lovely objects for study in every constellation.

The number of stars visible to the unaided eye in the northern sky is estimated at 3,000, and in the whole heavens at 5,000. It is within reasonable limits to say that a moderate sized telescope will show over 1,000,000 stars and the best instruments over 50,000,000. These are merely estimates to be sure, but they must be regarded as conservative.

In the star cluster known as the Galaxy, or Milky Way, to which our solar system belongs, the stars are almost innumerable. The better the telescope, and the greater the distance reached in the abyss of space by our perfected sounding-lines, the more millions of stars are added to the known Universe. Yet, all these are but as an atom to those that lie engulfed in the boundless realms beyond.

The distances, even of the stars nearest to us, are simply amazing. Using the diameter of the Earth's orbit, 185,000,000 of miles, as the longest available base line, the nearest star is so far removed, that the parallax ob-

tained is a quantity measured with extreme difficulty with the finest attainable instruments. This work has engaged the attention of competent astronomers for generations, but the results have been meagre. In only a few, perhaps a dozen instances, have even approximate measurements been obtained.

The star known as 61 Cygni, one of our nearest neighbors, has, so far, yielded the most trustworthy results of any, giving a distance from the Sun of about forty billions of miles. Only one nearer star has been found, Alpha Centauri, in the southern hemisphere, at about two-thirds the distance of 61 Cygni. Stars, which from their great brilliancy might reasonably have been thought to be less remote, have failed to show a measurable parallax. Most of the stars are therefore many times farther away.

If, as Herschel assumed, the remote stars taken in mass, will average of about the same actual size and brightness of those in the space near by, then we have a way to make something of an estimate of their distance. The best telescopes penetrate about 1,000 time farther into space than does the unaided eye. If the just visible points seen in a great telescope are 1,000 times more remote than 61 Cygni, we have the enormous distance of 40,000,000,000,000 of miles. Let the curious reader figure out, if he wishes, how long it would take a railway train, a cannon ball, or sound, or light, to traverse that distance.

This is but one-half the diameter of the sphere embracing the limits of our vision in every direction from our tiny earth observatory. Yet, men still continue to egotistically magnify themselves, and to believe that the Universe was created; and only, or mainly, for the use and pleasure of their pigmy race.

As the distances are too great to be measured, it follows that the real sizes of the fixed stars can only be left to conjecture. This statement receives added force from the fact that no fixed star has yet shown a sensible disk in a telescope. When best defined, the image of the star, though dazzling in brilliancy, is still only a point of light. When we consider the immensity of their distances, we are prepared to believe that many of them must far surpass our sun in size and grandeur. Certainly, Sirius, taking account of its great distance, is in fact many times more brilliant than the Sun. This must also be true of Arcturus, Vega, Capella and many others. At the comparatively shorter distance of 61 Cygni, our sun might be detected by close attention, but it would be an insignificant object among the stellar hosts. The Earth would be invisible with telescopes.

Satellites revolve around planets, planets around the Sun, and the question naturally arises whether the Sun is at rest, or moving with his attendant worlds along a mighty orbit. We have found by direct observation and careful measurement in the case of binary and multiple systems that some star-suns do in fact revolve around primaries, and in a few their periods have been determined. It is more than doubtful if any celestial body could maintain its equilibrium and remain at rest. So far as is positively known all are in motion. They move in an orderly manner around some central body or around a center of gravity common to two or more of them. These systems are themselves moving rapidly through space. If we reason from analogy, we are led to think that they are also in their flight moving in elliptical orbits.

Herschel discovered that our sun is moving toward a certain point in the constellation Hercules. Though the motion is more rapid than that of a ball when fired from